

Electric fish plug in to communicate

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Sternopygus macrurus. Photo by Galtier Delbosc, M. (fishbase.org)

(PhysOrg.com) -- Just as people plug in to computers, smart phones and electric outlets to communicate, electric fish communicate by quickly plugging special channels into their cells to generate electrical impulses, University of Texas at Austin researchers have discovered.

The fish generate electric fields to navigate, fight and attract mates in murky streams and rivers throughout Central and South America. They do so at night, while trying to avoid predators such as catfish that sense the electric fields.

Generating electricity is costly (ask any homeowner paying for air conditioning during a hot summer), and the fish are using a dimmer switch to save energy by turning their electrical signals up and down, says Harold Zakon, professor of [neurobiology](#).

Zakon, Michael Markham and Lynne McAnelly published their findings on the electric fish in *PLoS Biology* on Sept. 29.

They found that the dimmer switch comes in the form of [sodium channels](#) the fish insert and remove from the membranes of special cells, called electrocytes, within their electric organs. When more sodium channels are in the [cell membrane](#), the electric impulse emitted by the electric organ is greater.

The scientists also show that the process is under the control of hormones. And it is maintained through a day-night circadian rhythm and can change rapidly during social encounters.

"For a vertebrate animal, this is the first account that brings the whole system together from the behavior down to the rapid insertion of channels and in such an ecologically meaningful way," says Markham, a research scientist in the Zakon laboratory. "This is part of the animal's every day activity and it is being regulated very tightly by a low level molecular change."

Markham says the rapidity of the action is particularly stunning.

"This is happening within a matter of two to three minutes," he says. "The machinery is there to make this dramatic remodeling of the cell, and it does so within minutes from the time that some sort of stimulus is introduced in the environment."

The electric impulse can likely be produced so quickly because a reservoir of sodium channels is sitting in storage in the electric cells. When serotonin is released in the fish brain, it initiates the release of adrenocorticotrophic hormone from the pituitary gland. This gooses the mechanism that puts more sodium channels in the membrane.

"It's kind of like stepping on the gas in a car sitting there with its engine already running," says Zakon.

When the fish are inactive, they remove the sodium channels from the cell membranes to reduce the intensity of the electric impulse.

The electrocytes in the fishes' electric organ are made of modified muscle cells. This is significant because the vertebrate heart, which is also a muscle, can also add sodium channels to its cells to help it pump faster. The electric organ and heart are discharging constantly, and both organs are energetically costly.

"One big question for us in the future is, did this mechanism evolve once a long time ago or is this a case of convergent evolution, where the vertebrate heart evolved the ability to traffic these channels and then the electric organ evolved the same ability independently?" says Zakon.

More information: Markham MR, McAnelly ML, Stoddard PK, Zakon HH (2009) Circadian and Social Cues Regulate Ion Channel Trafficking. PLoS Biol 7(9): e1000203. [doi:10.1371/journal.pbio.1000203](https://doi.org/10.1371/journal.pbio.1000203)

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